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Essays on the U.S. financial cycle: construction, real effects and cross-border spill-overs

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CHAPTER 4

Financial and real integration between Mexico and the United States*

4.1 Introduction

The increasing importance of global factors in domestic macroeconomic fluctuations poses a problem with regard to the independence of monetary policy in small open economies.[1] These limitations have led to the development of macro-prudential regulatory frameworks (see, e.g., Kose, Otrok, & Whiteman, 2003). For instance, in Mexico the macro-prudential policy framework includes countercyclical capital buffers, loan-to-value ratios and limits on currency mismatches (see, e.g., Upper, 2017). To optimize macro-prudential frameworks, a better understanding of the extent and nature of international exposure is necessary.

The aim of this chapter is to quantify the exposure of the Mexican economy to U.S. cyclical factors. In particular, we study Mexican household and nonfinancial corporate leverage, its net financial account, real GDP growth rates and the stock market price index returns. We decompose their movements into domestic and U.S. short- and long-term cyclical components over 1981:Q1–2016:Q1. We also investigate subsample effects of the U.S. business cycle on the Mexican stock price index and real GDP growth rates. We do this separately for the early (1981:Q1–1999:Q4) and late (2000:Q1–2016:Q1) NAFTA periods. Our results suggest strong long- and short-term cyclical co-movements between Mexican and U.S. indicators.

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[1] These global factors include monetary policies of the Federal Reserve and of other major central banks (e.g., Rey, 2015).

Mexico is a small open economy with strong transmission of U.S. shocks due to its real and financial integration with the U.S. markets. Before 1996, domestic volatility swamped the role of U.S. factors in the fluctuations of macroeconomic indicators (see, e.g., Swiston & Bayoumi, 2008). The time period after 1995 is described as the Great Moderation of the Mexican business cycle, which exhibited less volatility in key macroeconomic indicators (Sosa, 2008). One explanation for this change in dynamics is an improvement in the monetary policy framework and a stronger fiscal position.

With regard to real integration, in 1994 the NAFTA agreement established a trilateral trade bloc between Canada, Mexico and the United States. As a result, cross-country correlations between macroeconomic aggregates increased, possibly due to similar responses to common shocks, idiosyncratic shocks that happened to be correlated across countries or spillover effects (Swiston & Bayoumi, 2008). Potential channels for spillovers include trade, wage remittances and capital flows (e.g. see López-Córdova, Hernández, & Monge-Naranjo, 2003; Kose, Meredith, & Towe, 2004; Arora & Vamvakidis, 2005; Sosa, 2008).

With regard to financial integration, rising risk-free U.S. benchmark rates tend to increase emerging market spreads through effects on cost, availability of funds and creditworthiness (Arora & Cerisola, 2001). These increasing market spreads can cause stability threats in that spreads typically first fall and then overshoot (Uribe & Yue, 2006). The effects of U.S. monetary shocks on emerging markets are substantial and explain an important part of fluctuations in macroeconomic variables (Canova, 2005; Mackowiak, 2007). Using data from more than 50 countries, Rey (2015) provides aggregate-level empirical evidence that emerging markets are subject to a global financial cycle in capital flows, asset prices and credit growth that co-moves with the Chicago Board Options Exchange Volatility Index (VIX), a measure of uncertainty and risk aversion of the markets.

These cycles also occur in Mexico. Beginning in 1998, foreign investment in Mexican banks began to increase financial integration. Before that, a foreign bank could not buy a Mexican bank whose market share exceeded 1.5%, and the limit on aggregate foreign bank participation was 8% of total market share. In the NAFTA period, changes in the legislation gradually eliminated restrictions on the entry of foreign capital, which led to foreign participation rising from 5.5% of total market share in 1993 to 67.2% in 2000 (Maudos & Solis, 2011).

The Mexican stock market was also closed to foreign investment until 1981. Thereafter, only one Mexican American depositary receipt was traded (see, e.g., Bekaert & Harvey, 1995). In 1989, the Mexican stock market opened to foreign investors with the exception of key sectors. Clark and Berko (1997) surmise that this broadening in the investor base increased risk sharing and liquidity, decreased expected returns and increased emerging market stock prices and covariance with the U.S. markets.[2]

We do not examine any specific transmission mechanism of U.S. shocks to the Mexican economy; rather, we investigate their aggregate effect, conceptually similar to Kose et al. (2004). They use a dynamic latent factor model with region- and country-specific factors to analyze Mexican output, consumption and investment series over the period 1980–2002. Herein, we study Mexico's household leverage, nonfinancial corporate leverage, GDP and stock price index growth and its net financial account flows. We analyze their short- and long-term cyclical co-movements with U.S. household and investor sentiment indicators. Short-term cyclical co-movements have business cycle length, and long-term co-movements have financial cycle length. Traditionally, business cycles have a period of two to eight years, whereas financial cycles' duration is more than eight years, and their average duration is approximately 16 years (see Drehmann, Borio, & Tsatsaronis, 2011; Galati, Koopman, Hindrayanto, & Vlekke, 2016; de Winter, Koopman, Hindrayanto, & Chouhan, 2017).

The distinction between the two types of cycles is relevant considering that Mexico's short- and long-term links to the United States may differ in nature. We analyze how the cyclical co-movement between U.S. GDP and Mexican GDP and stock price index growth rates changed from 1981:Q1–1999:Q1 to 2000:Q1–2016:Q1. We refer to the latter period as the late NAFTA subsample. We chose these subsamples because from 2000 onward, Mexico's banking sector and equity market were open to foreign participation and achieved monetary stability.

We find that the Mexican net financial account and leverage growth move pro-cyclically to U.S. investor sentiment in the short run but countercyclically in the long run. One explanation for the long-term negative investor sentiment-leverage relationship is that an upswing in the U.S. financial cycle is associated with more defaults in Mexico (see, e.g., Morais, Pedro & Ruiz, 2015). We estimate that in the long run, U.S. household sentiment is countercyclical to the Mexican net financial account, which implies a net outflow of foreign currency from Mexico when U.S. households expand their balance sheets. We observe short-term countercyclicality between U.S. GDP growth and Mexican non-financial corporate leverage and short-term pro-cyclicality between U.S. GDP growth and Mexican stock price index returns. We reason that positive foreign demand shocks can increase a firm's equity through increased profits, thus reducing its overall leverage and increasing its net value (see, e.g., Fernandez & Gulan, 2015). We find that U.S. business cycle effects became more

[2]A stock with a restricted investor base pays a premium, which is an increasing function of the stock's conditional variance, the narrowness of investor base and investor risk aversion.

important for the Mexican economy in the late NAFTA period. In the short run, U.S. GDP moves pro-cyclically to Mexican stock price index returns and to real GDP growth, which is not surprising, given that many Mexican companies are oriented toward the U.S. market.

The rest of this chapter is organized as follows: Section 4.2 describes our key macroeconomic indicators, Section 4.3 presents some stylized facts to motivate modeling choices and Section 4.4 describes the model. The estimation procedure is described in Section 4.5. Section 4.6 presents and discusses our findings, and Section 4.7 concludes.

4.2 Data

Our data set contains Mexican and U.S. quarterly macroeconomic indicators over the period 1981:Q1–2016:Q1. Along financial and business cycle frequencies, we analyze cyclical co-movements between Mexican and U.S. indicators.

The financial cycle reflects credit conditions and perceptions of value and risk. Traditionally, it is described with information in asset prices and credit variables (see, e.g., Borio, 2014; Drehmann, Borio, & Tstasaronis, 2011). Positive future cash-flow outlooks or sentiments increase asset prices and leverage. Herein, we distinguish between investor and household sentiment: whereas household sentiment depends on income and (expected) demand for real estate, investor sentiment depends on future profit expectations translated into capital asset prices and the conditions under which short- and long-term finance are available (see, e.g., Minsky, 1978). Previous studies show that indicators for household and corporate sentiments relate well to U.S. financial stress and crisis moments (Rozite, Bezemer & Jacobs, 2019).

Although several indicators are candidates to describe market sentiments ($\mathrm{FI}_{G,t}$), relatively few contain financial cycle frequency components. Our indicator for U.S. household sentiment is the quarter-on-quarter logarithmic growth rate of U.S. household leverage ($\mathrm{HHLEV}_{G,t}$). Household leverage is defined as credit extended to households scaled by wages and salaries. To construct the series, we collect information on U.S. credit market instruments for households and nonprofit organizations (liabilities) and information on wages and salaries reported in nominal terms and expressed in the local currency units from the Federal Reserve Bank of St. Louis. For the investor sentiment indicator, we use a measure developed in Baker and Wurgler (2006): ($\mathrm{SENT}_{\mathrm{U},t}$). Their index is based on the first principal component of five (standardized) sentiment proxies: the closed-end fund discount, which is the average difference between the net asset values of closed-end stock fund shares and their market prices; value-weighted dividend premium; the average first-day returns on IPOs; IPO volume and equity share in new issues. The sentiment index is not orthogonal to macroeconomic conditions; therefore, it also is a business cycle indicator. Our second indicator for the U.S. business cycle is the real U.S. GDP growth rate ($\mathrm{GDP}_{\mathrm{U},t}$).

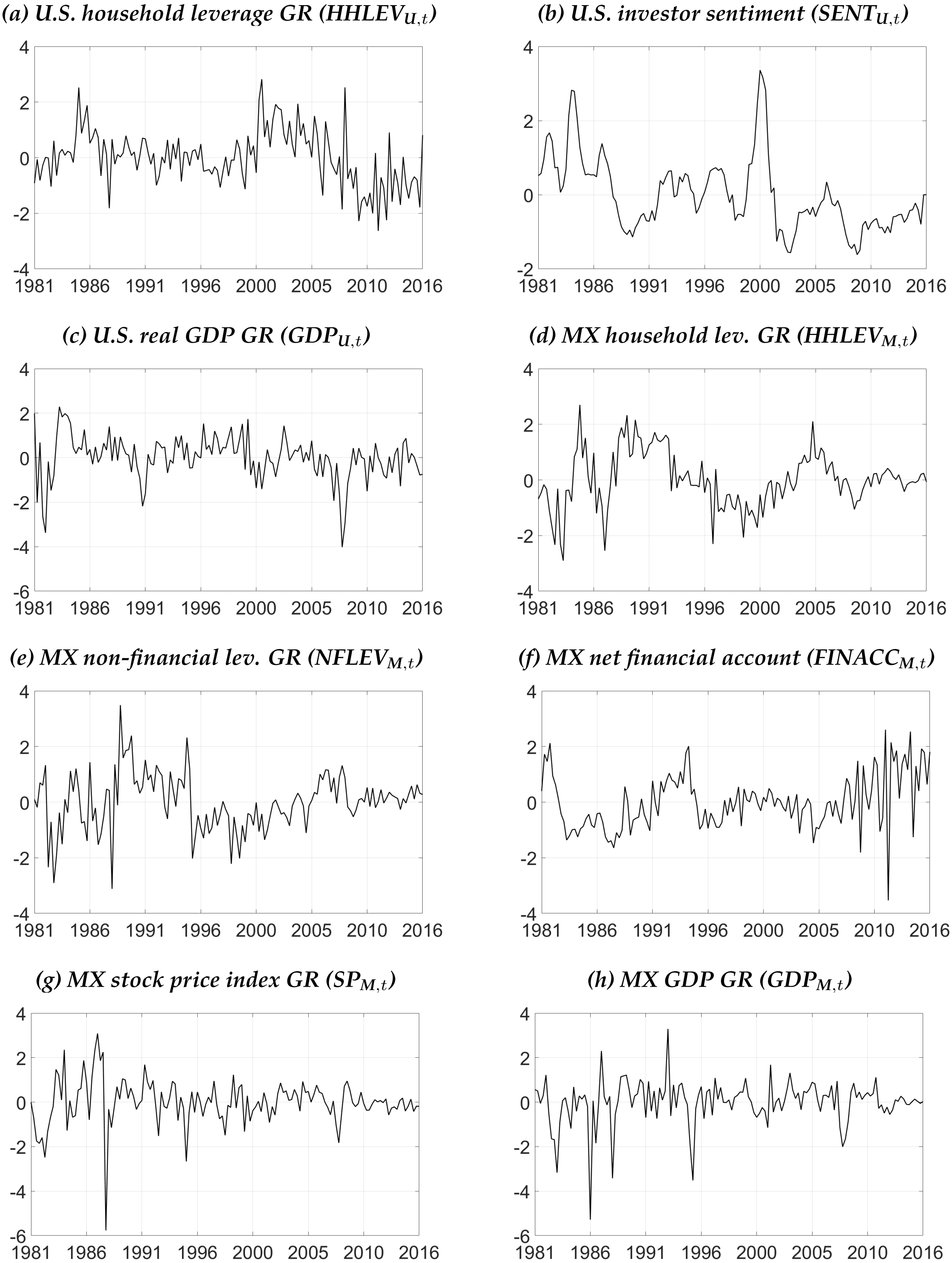
The selection of Mexican financial and real activity indicators is constrained by data availability. From Banco de México, we obtain the consumer price index (CPI) with reference year 2010; GDP in local currency units in nominal terms; loans to nonfinancial enterprises; consumption and mortgage loans to households in nominal terms and the Mexican stock price index with reference year 2010.[3] From the Federal Reserve Bank of St. Louis, we collect Mexican net financial account data, including changes in official reserves in U.S. dollars not seasonally adjusted. The net financial account shows claims or liabilities on financial assets held by nonresidents. These financial assets include direct investment, portfolio investment and reserve assets. We seasonally adjusted all Mexican financial and real activity indicators prior to modeling using the X-13 ARIMA-SEATS procedure in `Eviews` to keep the model parsimonious. We compute Mexican household leverage as total loans to households scaled with nominal GDP, of which quarter on quarter logarithmic growth rates ($\mathrm{HHLEV}_{\mathrm{M},t}$). Similarly, we construct nonfinancial corporate leverage growth rates ($\mathrm{NFLEV}_{\mathrm{M},t}$).[4] We adjust the Mexican stock price index and nominal GDP for inflation using the CPI and convert it to quarter-on-quarter logarithmic growth rates ($\mathrm{SP}_{\mathrm{M},t}$, $\mathrm{GDP}_{\mathrm{M},t}$). The Mexican net financial account in current U.S. dollars is scaled by the U.S. GDP deflator ($\mathrm{FINACC}_{\mathrm{M},t}$). To check the timing of peaks and troughs in the Mexican indicators, we collect the Organisation for Economic Co-operation and Development (OECD) recession indicator for Mexico. The U.S. and Mexican indicators do not contain unit roots and are standardized (see Appendix C.3 for further details).

Figure 4.2.1 shows developments of the indicators. For cross-country comparison, we investigate our data in levels. The U.S. and Mexican credit statistics are from the Bank of International Settlement. Just before 2008, U.S. household debt reached close to 100% of GDP, but by the end of 2016, it had decreased to 80%. In comparison, Mexican household debt has steadily increased since the early 2000s, reaching around 16% of GDP in 2016. Since the early 2000s and until the end of the sample, Mexican

[3]Unfortunately, data on Mexico's real estate price index are available only from 2005; thus, we omitted this variable from our analysis.

[4]The data show a sharp decrease in credit levels from 1995 onward due to governmental rescue programs, during which loans were transferred to a mutual fund. It is not possible to correct for this occurrence because no information is available on separate positions regarding the amount of household and nonfinancial corporate credit transfers.

Figure 4.2.1: Standardized Mexican and U.S. macroeconomic and financial indicators



Notes: Data are seasonally adjusted. The abbreviation "GR" denotes growth rates.

nonfinancial corporate debt rose from 42% to 75% of GDP. In contrast, nonfinancial corporate debt in the United States mostly increased throughout the sample, reaching 250% of GDP in 2016. Since the early 2000s, Mexican stock market capitalization increased from 15% to 34% of GDP at the end of the sample. In comparison, U.S. stock market capitalization reached its peak of 146% of GDP in the 2000s, dropping to 93% in 2008 and then recovering to 140% of GDP by the end of sample. The Mexican net financial account has fluctuated around zero in the past 10 years. Relative to Mexican GDP, the most important indicator is Mexican nonfinancial corporate leverage, followed by the stock market index, household leverage and finally its net financial account.

For our model input, we transform nonstationary indicators into stationary growth rates. The common practice to do so is to use observations in levels and to model stationary components alongside nonstationary trends using, for example, model-based filters. The resulting cycles are called growth cycles. We deviate from this practice for several reasons. First, modeling stochastic trends is not of direct interest in our case because we are primarily interested in growth rate cycles. Layton and Moore (1989) note that a growth rate cycle is an alternative to growth cycles, although they are more volatile, which makes identification of turning points more difficult.[5] Second, the econometric model–based approaches to detrending frequently are subject to calibration choices and can generate spurious cycles (e.g., Harvey & Jaeger, 1993). Because it is empirically difficult to isolate a stochastic trend due to its weak signal-to-noise ratio, estimations are facilitated by calibrating the stochastic trend parameters.[6] Third, we difference our data because the process we observe could have higher frequency components than a sampling frequency, which results in an phenomena known as aliasing, in which high-frequency components are erroneously translated to low frequencies, which may be confused for actual trends.

Instead of modeling stochastic trends, we can use nonparametric detrending methods such as Hodrick and Prescott (1997) or the band-pass filters of Baxter and King (1999) and Christiano and Fitzgerald (2003), which require prior assumptions on the length of the cycle. As a result of these prior assumptions, estimation problems may be encountered. For example, low frequency cycles outside the prespecified band can be classified as part of the long-term trend (see, e.g., Cogley & Nason, 1995; Comin & Gertler, 2006; Igan, Kabundi, Simone, Pinheiro, & Tamirisa, 2009; Galati, Koopman Hindrayanto, & Vlekke, 2016). These considerations guided our choice to calculate

[5] Turning points are identified using smoothed growth rates.

[6] These choices are based on the objective of obtaining smoothness and some persistence of the long-term trend.

quarter-on-quarter growth rates of nonstationary data.

4.3 Stylized Facts

Several mechanisms can cause co-movements between Mexican and U.S. financial and real activity indicators. First, many U.S. producers outsource part of their production process to Mexico, so we should observe a positive relation between Mexico's GDP growth on the one hand and U.S. GDP on the other. Second, we expect a positive relation between Mexican nonfinancial corporate leverage and stock price growth, as well as U.S. investor sentiment because U.S. investors are more likely to invest in Mexico when their sentiment is positive. For the same reason, we expect an increase in demand for Mexican financial assets. Thus, we should observe the Mexican net financial account to be pro-cyclical to U.S. sentiment indicators. Third, because Mexico generates a significant part of its wage income from the tourism industry, we expect a positive relation between U.S. household leverage growth on the one hand and Mexican GDP and household leverage growth on the other hand.

As a preliminary check of co-movements, we compute rank correlations between standardized Mexican and U.S. financial indicators. We use rank correlations rather than correlations because they assess monotonic rather than simply linear relationships. We note that Kose et al. (2004) caution against relying on correlations to make strong inference on co-movements because they capture only the contemporaneous co-movement and account for co-movement only in a single variable. In addition, correlations average over high- and low-frequency co-movements. With these caveats, Table 4.3.1 shows rank correlations for the full sample period and subsamples.

We observe no clear patterns that link U.S. and Mexican financial and real indicators. In the full sample and the two subsamples, Mexican household and nonfinancial leverage ratios have the strongest correlation. In the full and the late NAFTA sample period, U.S. household leverage growth rates are correlated with Mexican nonfinancial leverage. However, we observe no correlation with Mexican household leverage in either the subsample or the full sample period. The Mexican net financial account is negatively correlated to U.S. household leverage growth rates.

Examining the 1981–1999 and the 2000–2016 subsamples, we find no general indication that correlations between the United States and Mexico increased for real or financial indicators. One exception is the correlation between U.S. GDP growth and Mexican stock price index returns. The U.S. investor sentiment index correlates with Mexican leverage indicators in the full and 1981–1999 sample periods but is consis-

Table 4.3.1: Kendall rank correlations for Mexican and U.S. economic activity indicators.

	$\text{HHLEV}_{\text{U},t}$	$\text{SENT}_{\text{U},t}$	$\text{GDP}_{\text{U},t}$	$\text{HHLEV}_{\text{M},t}$	$\text{NFLEV}_{\text{M},t}$	$\text{GDP}_{\text{M},t}$	$\text{SP}_{\text{M},t}$	
				1981–2016				
$\text{HHLEV}_{\text{U},t}$	1							
$\text{SENT}_{\text{U},t}$	0.066	1						
$\text{GDP}_{\text{U},t}$	0.011	0.118^b	1					
$\text{HHLEV}_{\text{M},t}$	0.030	-0.188^c	0.007	1				
$\text{NFLEV}_{\text{M},t}$	−0.082	-0.131^b	−0.089	0.458^c	1			
$\text{FINACC}_{\text{M},t}$	-0.166^c	−0.068	-0.171^c	−0.012	0.116^b	1		
$\text{GDP}_{\text{M},t}$	−0.009	−0.0635	0.060	0.018	0.020	−0.009	1	
$\text{SP}_{\text{M},t}$	0.124^b	−0.061	0.183^c	0.070	−0.079	-0.160^c	0.126^b	1
				1981–1999				
$\text{HHLEV}_{\text{U},t}$	1							
$\text{SENT}_{\text{U},t}$	−0.038	1						
$\text{GDP}_{\text{U},t}$	-0.148^a	0.090	1					
$\text{HHLEV}_{\text{M},t}$	0.080	-0.255^c	−0.06	1				
$\text{NFLEV}_{\text{M},t}$	−0.024	-0.170^b	−0.03	0.455^c	1			
$\text{FINACC}_{\text{M},t}$	-0.145^a	−0.056	-0.128^a	0.056	0.152^a	1		
$\text{GDP}_{\text{M},t}$	−0.013	−0.059	−0.044	0.010	0.132^a	0.105	1	
$\text{SP}_{\text{M},t}$	0.230^c	−0.058	0.132^a	0.015	−0.037	-0.208^c	0.08	1
				2000–2016				
$\text{HHLEV}_{\text{U},t}$	1							
$\text{SENT}_{\text{U},t}$	0.108	1						
$\text{GDP}_{\text{U},t}$	0.107	−0.058	1					
$\text{HHLEV}_{\text{M},t}$	−0.029	0.052	0.072	1				
$\text{NFLEV}_{\text{M},t}$	-0.162^b	0.061	-0.174^b	0.377^c	1			
$\text{FINACC}_{\text{M},t}$	-0.202^c	0.004	−0.124	−0.092	0.042	1		
$\text{GDP}_{\text{M},t}$	−0.033	−0.050	0.218^c	−0.002	-0.146^a	-0.144^a	1	
$\text{SP}_{\text{M},t}$	0.058	−0.072	0.255^c	0.133	-0.179^b	−0.110	0.217^c	1

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$, $\text{SENT}_{\text{U},t}$ is U.S. investor sentiment, $\text{HHLEV}_{\text{U},t}$ is U.S. household leverage growth rate (GR), $\text{GDP}_{\text{U},t}$ is U.S. GDP GR, $\text{HHLEV}_{\text{M},t}$ is Mexican household leverage GR, $\text{NFLEV}_{\text{M},t}$ is Mexican non-financial corporate leverage GR, $\text{FINACC}_{\text{M},t}$ is the Mexican net financial account, $\text{GDP}_{\text{M},t}$ is Mexican GDP GR, $\text{SP}_{\text{M},t}$ is Mexican stock price index GR. All indicators are standardized.

tently uncorrelated with Mexican GDP. Mexican and U.S. real GDPs are correlated only in the late NAFTA period.

Table 4.3.2 shows the timing of peaks and troughs in the indicators. We obtained these data using the BBQ turning point detection algorithm, which requires a few input parameters: a window length around a peak or trough, a minimum phase length and a minimum cycle length (see Harding & Pagan, 2002). For our sample, we set the window length at 12 quarters, the minimum phase length at 2 quarters and a minimum cycle length at 12 quarters.

Table 4.3.2: The turning points of U.S. and Mexican indicators.

Indicator	Peaks				Troughs			
$\text{HHLEV}_{\text{U},t}$	1985-1	1994-1	2001-3	2013-1	1987-4	2000-1	2012-1	
$\text{SENT}_{\text{U},t}$	1984-1	1993-1	2001-1	2007-1	1989-3	1998-4	2003-4	2009-4
$\text{GDP}_{\text{U},t}$	1987-4	2000-2	2003-3		1990-4	2001-3	2008-4	
$\text{HHLEV}_{\text{M},t}$	1984-4	1989-1	2005-4	2012-3	1987-1	1996-4	2009-3	
$\text{NFLEV}_{\text{M},t}$	1988-4	2008-4			1988-1	1998-4	2009-4	
$\text{FINACC}_{\text{M},t}$	1994-2	1998-4	2012-1		1987-3	1995-2	2009-4	
$\text{SP}_{\text{M},t}$	1987-1	1991-2	1999-2	2009-3	1987-4	1995-1	2008-4	
$\text{GDP}_{\text{M},t}$	1993-1	2002-2	2011-4		1986-1	1995-2	2008-4	2013-1

Notes: The turning points are documented using the BBQ algorithm of Bry and Boschan (1971), extended by Harding and Pagan (2002). We set the parameters for the algorithm as follows: a window length is 12 quarters, minimum phase length 2 quarters and minimum cycle length 12 quarters. See Notes of Table 4.3.1 for definitions of the indicators.

The results show that troughs of U.S. and Mexican financial indicators coincide during the Black Monday market crash in 1987 and during the Great Financial Crisis. Troughs of Mexican stock market returns and real GDP coincide during the Tequila Crisis in 1995. This episode is not reflected in the troughs of U.S. indicators, which supports specifying US indicators as exogenous to the Mexican economy. We also observe no clear patters regarding the peak-trough regularities between U.S. and Mexican leverage cycles.

Principal component analysis indicates that three to four factors suffice to model co-movements in the eight indicators.[7] Four factors explain 57% of total variance. Table 4.3.3 shows their factor loadings.

The first factor, labeled the Mexican financial cycle, loads most heavily on Mexican leverage growth. The second factor, labeled the global financial cycle, loads most heavily on U.S. household leverage growth, U.S. investor sentiment and the Mexican net capital account. The third factor has the highest loadings on Mexican stock price index returns and Mexican GDP growth; therefore, we label it the Mexican business cycle. The fourth factor loads most heavily on U.S. GDP growth, the Mexican net financial account and GDP growth. We label this factor the global business cycle. In

[7] Kaiser's criterion is to include all factors with eigenvalues equal to or exceeding one. We estimate three eigenvalues larger than one: 1.898, 1.479 and 1.142. Inspection of the scree plot indicates four factors.

Table 4.3.3: Factor analyses of indicator co-movements.

Indicator	Factor 1	Factor 2	Factor 3	Factor 4
$\text{HHLEV}_{\text{U},t}$	0.041	0.997	-0.002	0.013
$\text{SENT}_{\text{U},t}$	-0.273	0.242	-0.089	0.057
$\text{GDP}_{\text{U},t}$	-0.066	-0.063	0.109	0.489
$\text{HHLEV}_{\text{M},t}$	0.991	0.071	0.060	0.072
$\text{NFLEV}_{\text{M},t}$	0.602	-0.017	0.041	-0.213
$\text{FINACC}_{\text{M},t}$	0.042	-0.252	0.113	-0.570
$\text{SP}_{\text{M},t}$	-0.073	-0.047	0.307	0.407
$\text{GDP}_{\text{M},t}$	0.191	-0.041	0.972	0.115

Notes: Varimax rotation is applied on a three-factor space.

Section 4.4, we proceed on the assumption that co-movements in the indicators can be summarized with these four (cyclical) factors.

4.4 Model

This section introduces a model to investigate the roles of U.S. and Mexican financial and business cycles in describing the long- and short-term movements of Mexican macroeconomic indicators. Similar to Koopman et al. (2016), we define a state-space model such that indicators of a country can contain financial and business cycles (see also Koopman & Lucas, 2005). However, to analyze the cyclical dynamics of an emerging economy, one necessary extension is to link its indicators to the cyclical components of the global economy. In the case of Mexico, the role of the United States is important; thus, we must include both Mexican and U.S. financial and business cycle components.

We assign separate roles to the financial cycle components found in U.S. investor and household sentiment indicators. Whereas consumer sentiment depends on income and demand for real estate, investor sentiment depends on future profit expectations translated into capital asset prices and the conditions under which short- and long-term finance are available (Minsky, 1978). Thus, their effects on Mexican indicators may differ from consumer sentiment effects.

Let the N-vector $\boldsymbol{y}_t = [\boldsymbol{y}'_{\text{U},t}, \boldsymbol{y}'_{\text{M},t}]'$ contain stationary U.S. and Mexican indicators. Two variants of the observation vector for the United States are given by

$$\boldsymbol{y}_{\mathrm{U},t} = (\mathrm{HHLEV}_{\mathrm{U},t}\ \mathrm{GDP}_{\mathrm{U},t})' \quad \text{or} \quad \boldsymbol{y}_{\mathrm{U},t} = \mathrm{SENT}_{\mathrm{U},t}, \quad t = 1, \ldots, T$$

and Mexican indicators are given by

$$\boldsymbol{y}_{\mathrm{M},t} = (\mathrm{HHLEV}_{\mathrm{M},t}\ \mathrm{NFLEV}_{\mathrm{M},t}\ \mathrm{FINACC}_{\mathrm{M},t}\ \mathrm{SP}_{\mathrm{M},t}\ \mathrm{GDP}_{\mathrm{M},t})'$$

where U refers to the United States and M to Mexico. The observed indicators ($\boldsymbol{y}_t$) are related to unobserved cyclical components ($\boldsymbol{\alpha}_t$) defined by

$$\begin{aligned} \boldsymbol{y}_t &= \boldsymbol{Z}\boldsymbol{\alpha}_t + \boldsymbol{e}_t, \quad \boldsymbol{e}_t \sim N(\boldsymbol{0}, \boldsymbol{H}), \\ \boldsymbol{\alpha}_t &= \boldsymbol{T}\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t, \quad \boldsymbol{\eta}_t \sim N(\boldsymbol{0}, \boldsymbol{Q}) \end{aligned} \tag{4.1}$$

where the k-state vector $\boldsymbol{\alpha}_t = (\boldsymbol{\psi}'_{\mathrm{U},t}, \boldsymbol{\gamma}'_{\mathrm{U},t}, \boldsymbol{\psi}'_{M,t}, \boldsymbol{\gamma}'_{\mathrm{M},t})'$ collects long-term ($\boldsymbol{\psi}_{\mathrm{U},t}$) and short-term ($\boldsymbol{\gamma}_{\mathrm{U},t}$) cyclical components. Each cyclical component of the United States is of the form $\boldsymbol{\psi}_{G,t} = (\psi_{\mathrm{U},t}, \psi^*_{\mathrm{U},t})'$ and $\boldsymbol{\gamma}_{\mathrm{U},t} = (\gamma_{\mathrm{U},t}, \gamma^*_{\mathrm{U},t})'$, and Mexico is notated similarly. The components marked with an asterisk result from writing the trigonometric components in a recursive form and can be interpreted as the partial derivatives of a cycle.

The $(N \times k)$ matrix $\boldsymbol{Z} = [\boldsymbol{Z}_{\mathrm{U}}\ \boldsymbol{Z}_{\mathrm{M}}] \otimes \boldsymbol{e}'_1$ contains factor loadings for the U.S. and Mexican cyclical components. Using univariate analysis (discussed in Section 4.6.1), we determine that $\boldsymbol{Z}$ has two variants. If $\mathrm{FI}_{\mathrm{G},t}$ is defined as $\mathrm{HHLEV}_{\mathrm{U},t}$, and thus $\boldsymbol{y}_t = (\mathrm{HHLEV}_{\mathrm{U},t}\ \mathrm{GDP}_{\mathrm{U},t}\ \boldsymbol{y}'_{\mathrm{M},t})'$ then $\boldsymbol{Z}$ consists of

$$\boldsymbol{Z}_{\mathrm{U}} = \begin{pmatrix} 1 & 0 & * & * & * & 0 & 0 \\ 0 & 1 & * & * & * & * & * \end{pmatrix}', \quad \boldsymbol{Z}_{\mathrm{M}} = \begin{pmatrix} 0 & 0 & 1 & * & * & 0 & 0 \\ 0 & 0 & * & * & * & 1 & * \end{pmatrix}' \tag{4.2}$$

However, if $\mathrm{FI}_{\mathrm{U},t}$ is defined as $\mathrm{SENT}_{\mathrm{U},t}$, and thus $\boldsymbol{y}_t = (\mathrm{SENT}_{\mathrm{U},t}\ \boldsymbol{y}'_{\mathrm{M},t})'$, $\boldsymbol{Z}$ consists of

$$\boldsymbol{Z}_{\mathrm{U}} = \begin{pmatrix} 1 & * & * & * & 0 & 0 \\ 1 & * & * & * & * & * \end{pmatrix}', \quad \boldsymbol{Z}_{\mathrm{M}} = \begin{pmatrix} 0 & 1 & * & * & 0 & 0 \\ 0 & * & * & * & 1 & * \end{pmatrix}' \tag{4.3}$$

where $*$ denotes an unrestricted element and $\boldsymbol{e}'_1 = (1\ 0)$. $\boldsymbol{Z}_{\mathrm{U}}$ and $\boldsymbol{Z}_{\mathrm{M}}$ contain identification restrictions. To fix the scale of a cyclical component, we choose one observed indicator as a base and linked it to one cyclical component with a fixed factor loading equal to one (see, e.g., Koopman et al., 2005). We assume that none of the U.S. indicators is influenced by the Mexican indicators; thus, factor loadings for Mexican factors in U.S. series are zero. Other restrictions are based on univariate analysis (discussed in more detail in Section 4.6.1).

The (8×8) matrix $\boldsymbol{T} = \text{blkdiag}[\boldsymbol{R}_\psi, \boldsymbol{R}_\gamma, \boldsymbol{R}_\psi, \boldsymbol{R}_\gamma]$ is a block diagonal matrix and describes the state transition for long- and short-term U.S. and Mexican cyclical components. The cyclical components are specified in the form of a stochastic trigonometric cycle with a state transition matrix given by

$$\boldsymbol{R}_j = \phi_j \begin{pmatrix} \cos \lambda_j & \sin \lambda_j \\ -\sin \lambda_j & \cos \lambda_j \end{pmatrix}, \; j = \psi, \gamma, \tag{4.4}$$

where $\phi_j \in (0, 1)$ is a persistence parameter and $\lambda_j \in (2\pi/T, \pi)$ is a frequency parameter (see Harvey, 1989). The period of a cycle expressed in years is given by $P_j = (2\pi/\lambda_j)/4$.

Two sets of similar cycles are observable in the model. First, the Mexican and U.S. business cycles are similar. Second, the Mexican and U.S. financial cycles are restricted to be similar. Therefore, they share the same frequency and persistence parameters (see Harvey & Koopman, 1997). Note, however, that similar cycles can still have different peaks and troughs and scales.

The (8×8) matrix $\boldsymbol{Q} = \text{diag}[\sigma^2_{\psi_\text{U}}, \sigma^2_{\gamma_\text{U}}, \sigma^2_{\psi_\text{M}}, \sigma^2_{\gamma_\text{M}}] \otimes \boldsymbol{I}_2$ and the $(N \times N)$ matrix $\boldsymbol{H}$ are both diagonal and positive definite. To shed light on the relative importance of each factor, we can decompose the covariance of observed indicators into the cyclical variance resulting from each factor and the noise part given by

$$\boldsymbol{\Sigma_y} = \boldsymbol{Z}\boldsymbol{P}\boldsymbol{Z}' + \boldsymbol{H}, \tag{4.5}$$

where $\boldsymbol{P}$ has elements given by $\text{vec}(\boldsymbol{P}) = \boldsymbol{I}_{64} - (\boldsymbol{T} \otimes \boldsymbol{T})^{-1}\boldsymbol{Q}$ and $\boldsymbol{H}$ is the noise part.

4.5 Estimation strategy

We estimate model (4.1) by maximizing the log-likelihood over the set of model parameter values ($\boldsymbol{\delta}$). We then use the parameters to filter the unobserved states using a Kalman filter. Finally, we apply the Kalman smoother, which improves a Kalman filter estimate of unobserved states at time t by using the full sample information (see, e.g., Durbin & Koopman, 2001).

Because all the state variables are covariance stationary, we set their initial values to have unconditional distributions. For example, the initial state of the U.S. long-term cyclical component is distributed as $\psi_{U,0} \sim N(0, \sigma^2_{\psi_U}/(1-\phi^2_{\psi_U}))$.

To implement the optimization process without constraints, we reparametrized some model parameters (in line with, e.g., Koopman & Azevedo, 2007). A typical diagonal element of a covariance matrix is specified as $\exp(2c_i)$ for some $c_i \in \mathbb{R}$. A cyclical component ψ_t has a period $P_\psi = \exp(\theta)$, where $\theta \in \mathbb{R}$; thus, the corresponding frequency parameter is $\lambda_\psi = 2\pi/P_\psi$. A persistence parameter for a cyclical component is parametrized as $\phi_\psi = \exp(\nu)/(1+\exp(\nu))$ for some $\nu \in \mathbb{R}$.

Our model is linear and Gaussian with linear constraints on parameters. Thus, finding the global maximum in theory does not constitute a problem. To improve the parameter empirical identification, which may be inhibited by flat likelihood regions, we still choose to use the global optimization algorithm in `Matlab` (i.e., simulated annealing (`simulannealbnd`)). This algorithm perturbs all the parameter values simultaneously; therefore, in the second stage we optimize with local optimization methods to find even better parameter estimates. For this task, we invoke `fminsearch` and `fmincon`. In the process of maximizing log-likelihood ($\log L$), `fmincon` provides the Hessian matrix, which we then use to obtain the standard errors for the model parameters ($\boldsymbol{\delta}$) by taking the square root of the diagonal entries of: $\boldsymbol{\Omega} = [-\partial^2 \log L/\partial\boldsymbol{\delta}\boldsymbol{\delta}']^{-1}$.

4.6 Results

In this section, we estimate short- and long-term cyclical co-movements between U.S. and Mexican macroeconomic indicators. Section 4.6.1 motivates the specification choices for the multivariate model described in Section 4.4. Section 4.6.2 estimates U.S. financial and business cycle effects for the Mexican economy during 1981–2016. In Section 4.6.3, we study the two subsamples to determine how the short-term cyclical dynamics of the Mexican indicators has changed from 1981–1999 to 2000–2016.

4.6.1 Univariate analysis

The literature classifies all growth (rate) cycle components into two groups: short-term cycles with periodicity from 2 to 8 years describe a business cycle, whereas components from 8 to 30 years describe a financial cycle (see, e.g., Drehmann et al., 2011). Each indicator can contain several business and financial cycle components. The first objective of this section is to estimate the strongest two for each indicator separately. A priori, we do not impose that each univariate model should contain one financial and one business cycle component. Thus, it is possible that both extracted cyclical components correspond either to a financial or a business cycle frequency. The second objective is to classify each variable as a business cycle indicator and/ or a financial cycle indicator. We incorporate these findings into the specification of the factor loading matrices shown in Section 4.4. Last, across both groups and all the indicators we compare how similar cyclical components, obtained from univariate models, are. We consider cycles similar if they share the same frequency and persistence parameters but retain distinct stochastic innovations. A multivariate similar cycle model is more parsimonious in parameters but may be too restrictive for the data.

For univariate estimations, we adopt the multivariate model described in Section 4.4. Further specification details can be found in Appendix C. We estimate two cyclical and one idiosyncratic component for each indicator. Table 4.6.1 lists both cycles in the increasing order of their cycle length. Each cyclical component is described by persistence ($\hat{\phi}_1$, $\hat{\phi}_2$), frequency, ($\hat{\lambda}_1$, $\hat{\lambda}_2$), cycle length in years (P_1, P_2) and state innovation variance ($\hat{\sigma}_1^2$,$\hat{\sigma}_2^2$). An idiosyncratic term is described by its measurement error variance ($\hat{\sigma}_\epsilon^2$).

Table 4.6.1 shows that U.S. household leverage growth rates ($\text{HHLEV}_{\text{U},t}$) contain only a 17-year-long ($P_1 = 17$) financial cycle component. The other cyclical component has a periodicity ($P_1 = 1$) of one year and is likely to capture some remaining seasonal variation. We omit the latter from further analysis.

Four indicators contain business and financial cycles. U.S. investor sentiment ($\text{SENT}_{\text{U},t}$) contains a 4-year-long ($P_1 = 4$) and a 17-year-long ($P_2 = 17$) cyclical component. The indicator has no noise term because it is the first principal component of multiple averaged financial market series (see Baker & Wurgler, 2006). Financial and business cycles are also present in Mexican household and noncorporate leverage growth and the Mexican net financial account. The shortest business cycle component is in the Mexican nonfinancial corporate leverage growth; it takes on average three years. We estimate that the longest business cycle component is found in the Mexican net financial account, with an average of six years.

Several indicators contain only business cycle components. U.S. and Mexican GDP growth rates contain the longest business cycle components, taking on average five years ($P_2 = 5$) and exhibiting similar persistence. The shortest business cycle components, two years, are in Mexican stock price index returns and GDP growth rates.

For all business (financial) cycle components, we sequence the estimated cycle length. We find that the median length of a business cycle is four years. The mode values for business cycle length are five and four years. For a financial cycle duration,

Table 4.6.1: Business and financial cycle components found in univariate model estimations.

Indicators	cycle 1				cycle 2				noise	
	$\hat{\phi}_1$	$\hat{\lambda}_1$	P_1	$\hat{\sigma}_1^2$	$\hat{\phi}_2$	$\hat{\lambda}_2$	P_2	$\hat{\sigma}_2^2$	$\hat{\sigma}_\epsilon^2$	$\log L$
				Financial cycle indicators						
$\mathrm{HHLEV}_{\mathrm{U},t}$	0.773^c	2.859^c	1	0.120	0.984	0.090	17	0.013	0.354^c	-168
	(0.110)	(0.111)		(0.115)	(0.024)	(0.015)		(0.014)	(0.147)	
				Business and Financial cycle indicators						
$\mathrm{SENT}_{\mathrm{U},t}$	0.887^c	0.446^c	4	0.028^b	0.923^c	0.095^c	17	0.030^c	0.000	-6
	(0.046)	(0.070)		(0.015)	(0.037)	(0.052)		(0.015)	(0.000)	
$\mathrm{HHLEV}_{\mathrm{M},t}$	0.937^c	0.352^c	5	0.030^c	0.983^c	0.099^c	16	0.011^a	0.293	-147
	(0.031)	(0.037)		(0.014)	(0.014)	(0.014)		(0.007)	(0.041)	
$\mathrm{NFLEV}_{\mathrm{M},t}$	0.820^c	0.501^b	3	0.048^a	0.984^c	0.092^c	17	0.007^a	0.322^c	-151
	(0.096)	(0.110)		(0.030)	(0.014)	(0.014)		(0.005)	(0.052)	
$\mathrm{FINACC}_{\mathrm{M},t}$	0.837^c	0.273	6	0.031	0.962^c	0.108^c	15	0.019	0.034^c	-164
	(0.169)	(0.237)		(0.057)	(0.042)	(0.035)		(0.022)	(0.061)	
				Business cycle indicators						
$\mathrm{GDP}_{\mathrm{U},t}$	0.996^c	0.425^c	4	0.002^c	0.763^c	0.346^b	5	0.156^c	0.347^c	-168
	(0.021)	(0.054)		(0.010)	(0.110)	(0.108)		(0.076)	(0.071)	
$\mathrm{SP}_{\mathrm{M},t}$	0.979^c	0.774^c	2	0.003	0.768^c	0.414^c	4	0.087	0.289^c	-151
	(0.021)	(0.020)		(0.004)	(0.104)	(0.108)		(0.043)	(0.051)	
$\mathrm{GDP}_{\mathrm{M},t}$	0.946^c	0.862^c	2	0.010	0.755^c	0.334^c	5	0.038	0.326^c	-148
	(0.041)	(0.040)		(0.009)	(0.216)	(0.199)		(0.045)	(0.057	

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. For each indicator, cycle 1 is shorter than cycle 2. Cycles are described with parameters: λ_i is a frequency, ϕ_i is a persistence, $\hat{\sigma}_i^2, i = 1, 2$ is a variance of the cyclical innovations and $P_i, i = 1, 2$ is a cycle period in years calculated as $P_i = (2\pi/\lambda_i)/4$. Idiosyncratic term has a variance parameter $\hat{\sigma}_\epsilon^2$. $\mathrm{FINACC}_{\mathrm{M},t}$ also contains a third cyclical component with $\lambda = 2.621$, not reported.

both the median and mode values are 17 years. All the estimated financial cycle components have high persistence and relatively similar frequencies. Thus, the assumption of similar financial cycles seems to be well founded. The five-year business cycles have persistence parameters, which are slightly more similar when compared with the four-year cycles. We observe that business cycle components have smaller persistence when compared with financial cycles. Overall, the assumption of similar business cycle components seems to be more restrictive. Still, in the multivariate analysis we assume that Mexican indicators can be described with two pairs of similar cycles representing the U.S. and Mexican financial and business cycles.

4.6.2 Multivariate analysis

In this section, we analyze long- and short-term co-movements between the U.S. and Mexican indicators. The univariate analyses shows that both U.S. household leverage growth rates and investor sentiment index contain a 17-year-long financial cycle component. Despite this similarity, consumer and investor sentiment effects on Mexican indicators may differ (see Section 4.4). Thus, we measure U.S. market sentiment with U.S. household leverage growth ($\mathrm{FI}_t = \mathrm{HHLEV}_{\mathrm{U},t}$) or, alternatively, with the U.S. investor sentiment index ($\mathrm{FI}_t = \mathrm{SENT}_{\mathrm{U},t}$).

The univariate analyses shows that U.S. household leverage growth rates contain a financial but not a business cycle component. Thus, our first identifying restriction is that the U.S. financial cycle explains 100% of cyclical variation in the U.S. household leverage growth. To identify the U.S. business cycle, our observation vector includes U.S. GDP growth rates. Our second identifying restriction is that 100% of cyclical movements in U.S. GDP growth rates are due to the U.S. business cycle. For our alternative model specification, we measure U.S. market sentiment with Baker and Wurgler's investor sentiment index (Baker & Wurgler, 2006). The univariate analysis shows that the U.S. investor sentiment index contains financial and business cycle frequencies. Therefore, our identifying restrictions are that 100% of its short-term cyclical movements are due to the U.S. business cycle and 100% of the long-term movements are due to the U.S. financial cycle. For Mexico, our identifying restriction is that all the cyclical movements in Mexican stock price index growth rates that are not due to the U.S. business cycle are explained by the Mexican business cycle. Our last identifying restriction is that all the long-term cyclical movements that are not due to the U.S. financial or business cycles or the Mexican business cycle are explained by the Mexican financial cycle.

Table 4.6.2 shows the estimated co-movements between U.S. and Mexican cyclical components. Each cyclical component is linked to its reference indicator with the factor loading one. In terms of magnitude, a statistically significant factor loading above one indicates that an indicator has a stronger association with a cyclical component than with its reference indicator. Sign-wise, a negative (positive) factor loading indicates a countercyclical (pro-cyclical) co-movement with respect to its reference indicator.

Table 4.6.2: Factor loadings describing the United States' and Mexico's financial and real integration.

	Household sentiment					Investor sentiment				
	U.S.		MX			U.S.		MX		
$\boldsymbol{y}_t$	$\psi_{U,t}$	$\gamma_{U,t}$	$\psi_{M,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\psi_{U,t}$	$\gamma_{U,t}$	$\psi_{M,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$
	Factor loadings $[\boldsymbol{Z}_G, \boldsymbol{Z}_M]$				$H(i,i)$	Factor loadings $[\boldsymbol{Z}_G, \boldsymbol{Z}_M]$				$H(i,i)$
$\text{FI}_{\text{U},t}$	1	0	0	0	0.584^c	1	1	0	0	0
$\text{GDP}_{\text{U},t}$	0	1	0	0	0.486^c	NA	NA	NA	NA	NA
$\text{HHLEV}_{\text{M},t}$	0.686^a (0.416)	-0.109 (0.161)	1	-2.662^a (1.476)	0.275^c	-0.496^b (0.222)	0.556^a (0.310)	1	-0.451^c (0.173)	0.249^c
$\text{NFLEV}_{\text{M},t}$	0.302 (0.321)	-0.337^b (0.163)	0.775^c (0.100)	-2.148^a (1.203)	0.515^c	-0.525^c (0.183)	0.928^b (0.389)	0.508^c (0.129)	-0.274 (0.200)	0.487^c
$\text{FINACC}_{\text{M},t}$	-0.698^c (0.191)	-0.438^c (0.161)	-0.210 (0.153)	-1.206^a (0.754)	0.625^c	-0.397^c (0.141)	0.738^b (0.361)	-0.542^b (0.230)	-0.278 (0.192)	0.582^c
$\text{SP}_{\text{M},t}$	0	0.574^c (0.163)	0	1	0.806^c	0	-0.086 (0.352)	0	1	0.609^c
$\text{GDP}_{\text{M},t}$	0	0.173 (0.151)	0	-1.035 (0.854)	0.919^c	0	0.522 (0.329)	0	0.530^b (0.226)	0.834^c
λ_i	0.080^c	0.332^c	0.080^c	0.332^c		0.118^c	0.436^c	0.118^c	0.436^c	
P_i	20	5	20	5		13	4	13	4	
ϕ_i	0.995^c	0.888^c	0.995^c	0.888^c		0.942^c	0.859^c	0.942^c	0.859^c	
$\boldsymbol{Q}$	0.007^c	0.123^c	0.003^c	0.009^c		0.080^c	0.046^c	0.055^c	0.122^c	
$\log L$	-1226					-941				

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. The standard errors for the coefficients are reported in brackets. In the table, a factor loading one indicates which observed series were used as a reference for an unobserved cyclical component, and a loading of zero excludes a factor from an indicator. Cyclical components considered are $\psi_{U,t}$, a global financial cycle; $\gamma_{U,t}$, a global business cycle; $\psi_{M,t}$, a Mexican financial cycle; $\gamma_{M,t}$, a Mexican business cycle and $\sigma_{\epsilon,i}$, a noise component. Zero factor loadings not reported here are for $\psi^*_{U,t}$, $\gamma^*_{U,t}$, $\psi^*_{M,t}$ and $\gamma^*_{M,t}$. $H(i,i)$ denotes the ith diagonal element of the matrix $\boldsymbol{H}$. We define $\text{FI}_{G,t} = \text{HHLEV}_{t,G}$ for the "Household sentiment" block and $\text{FI}_{G,t} = \text{SENT}_{t,G}$ for the "Investor sentiment" block.

The left-hand side of Table 4.6.2, labeled "Household sentiment," shows several noteworthy patterns. We observe long-term countercyclicality between U.S. household leverage growth and the Mexican net financial account. The two main subaccounts of a net financial account are domestic ownership of foreign assets and foreign ownership of domestic assets. A negative value of the net financial account implies an outflow of money. Thus, Mexican investors tend to acquire foreign-owned assets when U.S. households expand their balance sheets. We also observe long-term pro-cyclicality between U.S. and Mexican household leverage growth rates.

We observe short-term countercyclicality between U.S. GDP growth and the Mexican net financial account and its nonfinancial corporate leverage growth rates. However, U.S. GDP growth rates are short-term pro-cyclical to Mexican stock price index returns. We infer that Mexican investors acquire foreign-owned assets when the U.S. economy grows and Mexican non-financial corporate leverage decreases. The origins of countercyclicality between Mexican nonfinancial corporate leverage and U.S. GDP growth rates are not immediately clear. One possibility is that a positive U.S. productivity shock increases the net worth of Mexican entrepreneurs through the export channel, thereby reducing their leverage. Following a positive (foreign) demand shock, an initially leveraged entrepreneur will earn higher profits, increase equity by more than debt and therefore deleverage (see, e.g., Fernández & Gulan, 2015). These results implies that leverage and firms' asset values move in opposite directions.

We also observe cyclical co-movements shared by Mexican indicators only. First, we estimate long-term pro-cyclicality between Mexican household and corporate leverage growth. Co-movements of these variables describe the Mexican financial cycle. Second, we observe short-term countercyclicality between the Mexican net financial account, leverage and the stock market price index growth rates. Thus, Mexicans acquire foreign-owned assets as Mexican leverage decreases and stock price index returns increase. In this estimation block, the combination of these variables define a Mexican business cycle.

The right-hand side of Table 4.6.2, labeled "Investor sentiment," provides additional insights into the indicator co-movements. Long-term countercyclicality is evident between U.S. investor sentiment and the Mexican net financial account. Thus, Mexican-owned assets increase as U.S. investor sentiment increases. We estimate that U.S. investor sentiment is long-term countercyclical to Mexican household and noncorporate leverage growth. This long-term countercyclicality may have several explanations. One possibility is that softening of foreign monetary policy increases the supply of loans by foreign banks to Mexican firms. In particular, it increases the supply of credit to borrowers with higher ex ante loan rates and with substantially higher ex post loan defaults. Thus, credit expansion to riskier firms leads to more risk-taking rather than to improved real outcomes (see e.g., Morais, Pedro & Ruiz, 2015).

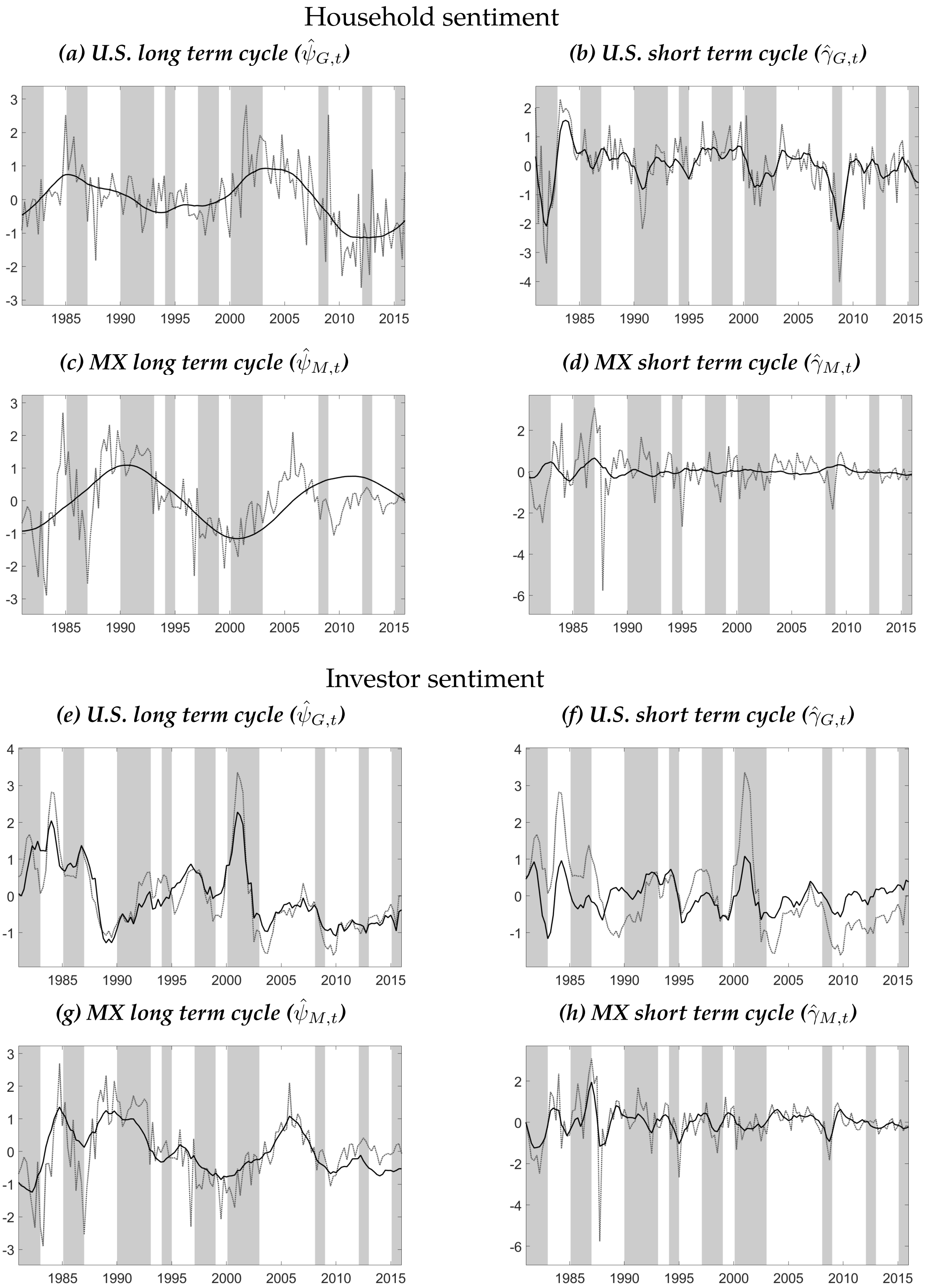
As expected, we observe short-term pro-cyclicality between U.S. investor sentiment and Mexican leverage ratios: positive global investor sentiment improves the likelihood of obtaining external finance. Simultaneously, we observe short-term pro-cyclicality between U.S. investor sentiment and the Mexican net financial account, which implies that Mexican-owned assets decrease with positive U.S. investor sentiment and expanding Mexican household and nonfinancial corporation balance sheets. Last, we observe short-term countercyclicality between Mexican household leverage growth, stock price index returns and GDP growth rates. Co-movements in these variables describe a Mexican business cycle.

Figure 4.6.1 shows the two blocks of four smoothed cyclical components, each of which contain U.S. and Mexican financial and business cycle components. We obtain smoothed cycles using the multivariate model described in Section 4.4 with the estimated parameter values shown in Table 4.6.2. A zero value for a cyclical component corresponds to the historical average: positive (negative) values indicate episodes above (below) historical average. Using U.S. household leverage and GDP growth rates as indicators for the U.S. market sentiments and business cycle, we estimate that financial cycles take 20 years and business cycles 4 years. Using the U.S. investor sentiment index, we determine the length of a financial cycle to be 13 years and a business cycle to be 4 years.

Next, we compute the contribution of each cyclical component in explaining variation in Mexican indicators. For orthogonal cyclical components, the variance decomposition is given by Eq.(4.5) with the input parameter values as shown in Table 4.6.2. For example, unconditional variance for a U.S. financial component is given by $\sigma^2_{\psi_{\mathrm{U}}}/(1-\phi^2_{\psi_{\mathrm{U}}})$. The amount of variance it explains in $\mathrm{HHLEV}_{\mathrm{M},t}$ is proportional to the corresponding squared factor loading. Table 4.6.3 shows variance decompositions.

Table 4.6.3 shows that most Mexican indicators have strong co-movements with the U.S. business and financial cycles. We find that approximately one-fourth of the Mexican household and corporate leverage growth has long-term co-movement with U.S. investor sentiment. Similarly, one fourth of Mexican household leverage growth rates has long run co-movement with the U.S. household sentiment. Approximately one-third of the Mexican net financial account in the long run co-moves with the U.S. household sentiment, and 12% has long-term co-movement with U.S. investor sentiment. We estimate that about one-fourth of the Mexican stock price index growth co-moves with the U.S. business cycle. However, Mexican GDP growth rates contain mostly idiosyncratic components. Given an increase in real integration between Mexico and the United States, the latter finding is surprising. Therefore, the next

Figure 4.6.1: U.S. and Mexican financial and business cycles.



Notes: Smoothed estimates of cycles are shown in black, their reference indicators in grey and Mexico's OECD recession dates as grey bars.

Table 4.6.3: Decomposition of variance for the Mexican indicators (%).

	$\mathrm{HHLEV}_{\mathrm{U},t}$					$\mathrm{SENT}_{\mathrm{U},t}$				
	US		MX			US		MX		
$\boldsymbol{y}_{\mathrm{M},t}$	$\psi_{\mathrm{U},t}$	$\gamma_{\mathrm{U},t}$	$\psi_{\mathrm{M},t}$	$\gamma_{\mathrm{M},t}$	$\epsilon_{i,t}$	$\psi_{\mathrm{U},t}$	$\gamma_{\mathrm{U},t}$	$\psi_{\mathrm{M},t}$	$\gamma_{\mathrm{M},t}$	$\epsilon_{i,t}$
$\mathrm{HHLEV}_{\mathrm{M},t}$	27	0	27	24	22	17	5	46	9	24
$\mathrm{NFLEV}_{\mathrm{M},t}$	0	7	21	20	53	20	16	13	0	51
$\mathrm{FINACC}_{\mathrm{M},t}$	31	10	0	5	54	12	10	15	0	62
$\mathrm{SP}_{\mathrm{M},t}$	0	18	0	4	77	0	0	0	43	57
$\mathrm{GDP}_{\mathrm{M},t}$	0	0	0	0	100	0	0	0	14	86

Notes: We compute percentage contribution of each cyclical component and of an idiosyncratic component to the Mexican indicator dynamics. We set all factor loadings to zero if their level of significance is less than 10% (see Table 4.6.2). Cyclical components considered are $\psi_{U,t}$, a U.S. financial cycle; $\gamma_{U,t}$, a U.S. business cycle; $\psi_{M,t}$, a Mexican financial cycle and $\gamma_{M,t}$, a Mexican business cycle. $\sigma_{\epsilon,i}$ is a noise component.

section investigates business cycle effects in the subsamples.

4.6.3 Exploring the role of NAFTA

As discussed by Kose, Meredith, and Towe (2004), NAFTA had an effect on trade and financial flows between Mexico and the United States.[8] Thus, the role of U.S. factors increased for the Mexican economy. Nevertheless, it is still difficult to isolate the NAFTA effects considering the markets anticipated part of it. Moreover, NAFTA led to gradual market liberalization over the first 10—15 years after the agreement was signed. In addition, Mexico and the United States signed other bilateral trade agreements, increasing their global exposure in general (see, e.g., Kose et al., 2004). Because NAFTA was implemented only gradually, 2000 serves as a good threshold year for a subsample analysis. By 2000, Mexico had opened up its banking sector and stock market to foreign participation, had begun to issue long-term treasury bonds and had stabilized its inflation level. Thus, it seems reasonable to assume that if there are any effects of the integration to be found, they should become visible from 2000 onward.

Keeping in mind that the late NAFTA subsample analysis provides only indirect evidence of trade liberalization effects, we now repeat the analysis from Section 4.6.2 for 1981:Q1–1999:Q4 and 2000:Q1–2016:Q1 subsamples with some modifications to the multivariate model. Because the number of observations in subsamples is not

[8]For example, trade barriers decreased, Mexico's exports shifted toward manufactured goods, intra-firm trade among the NAFTA partners increased, provisions for investor legal rights were established and so on.

sufficient to make any reliable inference for financial cycles, we exclude both financial cycle components from the vector of unobserved factors $\boldsymbol{\alpha}_t$. We also exclude all the indicators that load on them: U.S. and Mexican household leverage growth rates, the U.S. investor sentiment index, Mexican nonfinancial corporate leverage growth and the net financial account. For our observation matrices $\boldsymbol{Z}$s, we only keep columns that refer to factor loadings of global and Mexican business cycle components. For our unobserved cycles, one identifying restriction is that 100% of cyclical variation in the U.S. GDP growth is explained by the U.S. business cycle. The other restriction is that 100% of cyclical variation in Mexican stock price index growth rates not accounted for by the US business cycle is due to the Mexican business cycle. (Refer to Appendix C.2 for more details.)

Table 4.6.4 shows the subsample differences in effects of U.S. and Mexican business cycles on Mexican GDP and stock price index growth rates.

Table 4.6.4: Global and Mexican business cycle subsample effects on Mexican indicators.

$\boldsymbol{y}_t$	1981–1999			2000–2016			1981–2016		
	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$
	Factor loadings		$H(i,i)$	Factor loadings		$H(i,i)$	Factor loadings		$H(i,i)$
$\mathrm{GDP}_{\mathrm{U},t}$	1	0	0.471^c	1	0	0.452^c	1	0	0.440^c
$\mathrm{SP}_{\mathrm{M},t}$	0.481	1	1.073^c	0.475^c	1	0.148^c	0.495^c	1	0.771^c
	(0.301)			(0.140)			(0.178)		
$\mathrm{GDP}_{\mathrm{M},t}$	-0.174	0.841	1.222^c	0.669^c	-0.606	0.198^c	0.143	1.922	0.676^c
	(0.265)	(0.833)		(0.162)	(1.195)		(0.179)	(1.388)	
λ_i	0.465^c	0.465^c		0.532^c	0.523^c		0.430	0.430	
P_i	3	3		3	3		4	4	
ϕ_i	0.823^c	0.823^c		0.774^b	0.774^b		0.778^c	0.778^c	
$\boldsymbol{Q}$	0.182^c	0.131^c		0.179^c	0.010^c		0.201^c	0.035^c	
$\log L$	-343			-175			-569		

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. Standard errors are reported in brackets. Cyclical components considered are $\gamma_{U,t}$, a U.S. business cycle; $\gamma_{M,t}$, a Mexican business cycle; and $\sigma_{\epsilon,i}$, a noise component. In the table a factor loading one indicates which observed series we used as a reference for an unobserved cyclical component. Zero factor loadings not reported here are for $\gamma^*_{U,t}$ and $\gamma^*_{M,t}$. $H(i,i)$ denotes the ith diagonal elements of the matrix $\boldsymbol{H}$.

We estimate that in both subsamples, an average business cycle takes around three years. In the early subsample, we find no evidence of cyclical co-movement between any indicators. However, in the late NAFTA period, we observe short term-pro-cyclicality between U.S. and Mexican GDP growth and Mexican stock price index returns.

A cross-sample comparison of idiosyncratic variance ($\sigma^2_{\epsilon,i}$) shows a decrease for both indicators in the late NAFTA subsample. This finding is not surprising given that monetary stability with stable inflation and flexible exchange rate was achieved in the late 1990s. From 1999, a full-fledged inflation target became the focal point of Mexican monetary policy; Mexico issued its local currency bonds and had reduced its external debt (see, e.g., Carstens & Jácome, 2005). All of these factors helped shield Mexico from exchange rate shocks.

Following the same procedure as for the full sample results, we calculate the relative proportions of variance explained by U.S. and Mexican business cycles. The results are shown in Table 4.6.5. We find that both Mexican GDP and stock price index growth rates increased their exposure to U.S. business cycle component in the late NAFTA period. At the same time, the shares of idiosyncratic shocks decreased. These effects may be attributed to NAFTA; however, Mexican and U.S. global exposure in general has increased through other bilateral trade agreements.

Table 4.6.5: Decomposition of variance (%) for the Mexican indicators over the subsamples.

	1981–1999			2000–2016		
$\boldsymbol{y}_{M,t}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\epsilon_{i,t}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\epsilon_{i,t}$
$\text{SP}_{\text{M},t}$	0	27	73	37	9	54
$\text{GDP}_{\text{M},t}$	0	0	100	50	0	50

Notes: We compute percentage contribution of each cyclical component and of a component idiosyncratic to the Mexican indicator dynamics. We set all factor loadings to zero if their level of significance is less than 10% (see Table 4.6.4). Cyclical components considered are $\gamma_{U,t}$, a U.S. business cycle, and $\gamma_{M,t}$, a Mexican business cycle. $\sigma_{\epsilon,i}$ is a noise component.

We estimate that in the late NAFTA subsample, one-half of the Mexican GDP growth rate variance was driven by the U.S. business cycle. Approximately 40% of Mexican stock price index returns co-moved with the U.S. business cycle. Strong presence of global dynamics motivates the need to develop macro-prudential frameworks aimed at smoothing out global risks for a domestic economy. Our findings illustrate that Mexico's economic growth outlook is linked to economic developments in the United States.

4.7 Conclusion

Historically, Mexico has had tight trade ties with the United States. Since 2000, it has opened up its equity and banking sectors. Thus, many channels are available through which foreign financial and business cycles can be transmitted. In this context, understanding the scope of the domestic versus foreign dynamics is important. This chapter investigates the cyclical properties of Mexican economic and financial activity indicators. The indicators are decomposed into Mexican and U.S. business and financial cycle components. To extract U.S. financial cycle components, we select two reference indicators: First, household leverage growth rates reflect U.S. household sentiment, which depends on household income and demand for real estate. Second, as a reference for a U.S. financial cycle, we use the U.S. investor sentiment indicator, which depends on future profit expectations and capital asset prices. We find that factors extracted from these indicators link differently to Mexican indicators.

Our analysis provides several insights. First, Mexican household leverage and nonfinancial corporate leverage co-moves with the U.S. financial and business cycle. We observe long-term countercyclicality between U.S. investor sentiment and Mexican leverage ratios and short-term pro-cyclicality. This finding may reflect that supply of funds by foreign banks and easing of credit conditions increase risk taking and long-term default rates of economic agents. Consequently, an increase in default rates leads to negative long-term effects for leverage growth (Morais et al., 2015).

Second, we observe short term countercyclicality between U.S. GDP growth and Mexican nonfinancial corporate leverage growth. Similarly, U.S. GDP growth is short term countercyclical to the Mexican net financial account. Moreover, in the short run Mexican stock price index returns are pro-cyclical to U.S. GDP growth rates. Our interpretation is that a positive foreign demand shock increases domestic profits and equity, thus decreasing leverage. We do not observe this effect to be statistically significant for Mexican households.

Third, we observe long-term countercyclicality between the Mexican net financial account on the one hand and U.S. household and investor sentiment on the other. We also find a short term countercyclicality between U.S. GDP growth rates and the Mexican net financial account. Thus, Mexican investors acquire foreign held assets with an upswing in U.S. investor and household sentiments and as the U.S. economy grows.

In a separate analysis, we explore potential effects of NAFTA. We find that in the late NAFTA period, Mexican GDP growth rates and stock price index returns are short-term pro-cyclical to U.S. GDP growth. We estimate that idiosyncratic variation in Mexican GDP and stock price index returns has decreased in the late NAFTA subsample, which accords with the advent of monetary stability from 2000 onward when exchange rate risks were addressed through reduction of external debt, bonds denominated in local currency and the central bank's commitment to low inflation target. These findings imply that the role of the United States has increased for the Mexican economy.

Our analysis suggests, first, that economic forecasts for Mexico depend to a large extent on the U.S. outlook. Second, designing a macro-prudential framework that smooths out U.S. financial cycle effects on Mexican leverage growth rates could be beneficial for the Mexican economy. However, it is crucial to shed more light on the complex links between Mexican leverage growth dynamics, changes in Mexican asset ownership and the U.S. economy. We only briefly mention possible channels for financial and real cycles transmission; we leave measuring the importance of these channels to future research.

Appendix C.

C.1 Univariate Unobserved components time series model

Consider an observation vector at $t = 1, \dots, T$

$$\boldsymbol{y}_t = (\text{SENT}_{\text{U},t}\ \text{HHLEV}_{\text{U},t}\ \text{GDP}_{\text{U},t}\ \text{HHLEV}_{\text{M},t}\ \text{NFLEV}_{\text{M},t}\ \text{FINACC}_{\text{M},t}\ \text{SP}_{\text{M},t}\ \text{GDP}_{\text{M},t})',$$

where "U" refers to the US and "M" to Mexico. For each indicator $y_{i,t}$ the data generating process is given by

$$\begin{aligned} y_{i,t} &= \boldsymbol{z}\boldsymbol{\alpha}_{i,t} + e_{i,t},\ e_{i,t} \sim N(0, \sigma^2_{e,i}), \\ \boldsymbol{\alpha}_{i,t} &= \boldsymbol{T}_i\boldsymbol{\alpha}_{i,t-1} + \boldsymbol{\eta}_{i,t},\ \boldsymbol{\eta}_{i,t} \sim N(0, \boldsymbol{Q}_i) \end{aligned}$$

where $\boldsymbol{\alpha}_{i,t} = (c_{1,i,t}\ c^*_{1,i,t}\ c_{2,i,t}\ c^*_{2,i,t})'$ are cyclical, trigonometric components, $e_{i,t}$ and $\boldsymbol{\eta}_{i,t}$, are mutually independent error and state innovation terms, $\boldsymbol{z} = [1, 1] \otimes \boldsymbol{e}'_1$ contains factor loadings, $\boldsymbol{T}_i = \text{blkdiag}[\boldsymbol{R}_{c_1,i}, \boldsymbol{R}_{c_2,i}]$ is a block diagonal state transition matrix where rotation matrices are specified

$$\boldsymbol{R}_{j,i} = \phi_{c_1,i} \begin{pmatrix} \cos\lambda_{c_1,i} & \sin\lambda_{c_1,i} \\ -\sin\lambda_{c_1,i} & \cos\lambda_{c_1,i} \end{pmatrix},\ i = 1 \dots N;\ j = c_1,\ c_2$$

where $\phi_{c_1,i}$ is a persistence parameter, $\lambda_{c_1,i}$ a frequency, $\boldsymbol{Q}_i = \text{diag}[\sigma^2_{c_1,i}, \sigma^2_{c_2,i}] \otimes \boldsymbol{I}_2$ is a diagonal state innovation matrix. This implies that the two cyclical components are mutually independent.

C.2 Post NAFTA business cycle effects

Consider an observation vector at $t = 1, \dots, T$

$$\boldsymbol{y}_t = (\mathrm{GDP}_{\mathrm{U},t}\ \mathrm{SP}_{\mathrm{M},t}\ \mathrm{GDP}_{\mathrm{M},t})',$$

where U refers to the U.S. and M to Mexico. The observed indicators ($\boldsymbol{y}_t$) are related to unobserved cyclical components ($\boldsymbol{\alpha}_t$) defined by

$$\begin{aligned}\boldsymbol{y}_t &= \boldsymbol{Z}\boldsymbol{\alpha}_t + \boldsymbol{e}_t, \quad \boldsymbol{e}_t \sim N(\boldsymbol{0}, \boldsymbol{H}),\\ \boldsymbol{\alpha}_t &= \boldsymbol{T}\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t, \quad \boldsymbol{\eta}_t \sim N(\boldsymbol{0}, \boldsymbol{Q})\end{aligned}$$

where the k-state vector $\boldsymbol{\alpha}_t = (\boldsymbol{\gamma}'_{U,t}, \boldsymbol{\gamma}'_{M,t})'$ with short-term cyclical components. Each cyclical component of the U.S. is of the form $\boldsymbol{\gamma}_{U,t} = (\gamma_{U,t}, \gamma^*_{U,t})'$ and similarly for Mexico. The components marked with a superscript star result from writing the trigonometric components in a recursive form and can be interpreted as the partial derivatives of a cycle.

The observation matrix $\boldsymbol{Z} = \boldsymbol{Z}^* \otimes \boldsymbol{e}'_1$ is defined as

$$\boldsymbol{Z}^* = \begin{pmatrix} 1 & * & * \\ 0 & 1 & * \end{pmatrix}',$$

where $*$ denotes an unrestricted element and $\boldsymbol{e}'_1 = (1\ 0)$. The state transition matrix $\boldsymbol{T} = \boldsymbol{I}_2 \otimes \boldsymbol{R}_\gamma$ is defined by

$$\boldsymbol{R}_\gamma = \phi_\gamma \begin{pmatrix} \cos\lambda_\gamma & \sin\lambda_\gamma \\ -\sin\lambda_\gamma & \cos\lambda_\gamma \end{pmatrix},$$

where the persistence parameter $\phi_\gamma \in (0,1)$ and $\lambda_\gamma \in (2\pi/T, \pi)$ is a frequency parameter.

C.3 Unit root tests

Table C.3.1: Dickey Fuller unit root test

$y_{i,t}$	probability	t-stats	lags
$\mathrm{SENT}_{\mathrm{U},t}$	0.007	-3.584	1
$\mathrm{HHLEV}_{\mathrm{U},t}$	0.051	-2.873	2
$\mathrm{GDP}_{\mathrm{U},t}$	0.000	-4.707	1
$\mathrm{HHLEV}_{\mathrm{M},t}$	0.051	-2.873	2
$\mathrm{NFLEV}_{\mathrm{M},t}$	0.002	-4.002	1
$\mathrm{FINACC}_{\mathrm{M},t}$	0.038	-2.989	3
$\mathrm{GDP}_{\mathrm{M},t}$	0.000	-8.701	1
$\mathrm{SP}_{\mathrm{M},t}$	0.000	-7.100	1

Notes: $y_{i,t}$ is a financial indicator where $i = 1, \ldots, 8$. The lag order was detected using Akaike's information criteria (AIC) information criteria. We cannot accept unit roots in the current data sample 1981–2006.